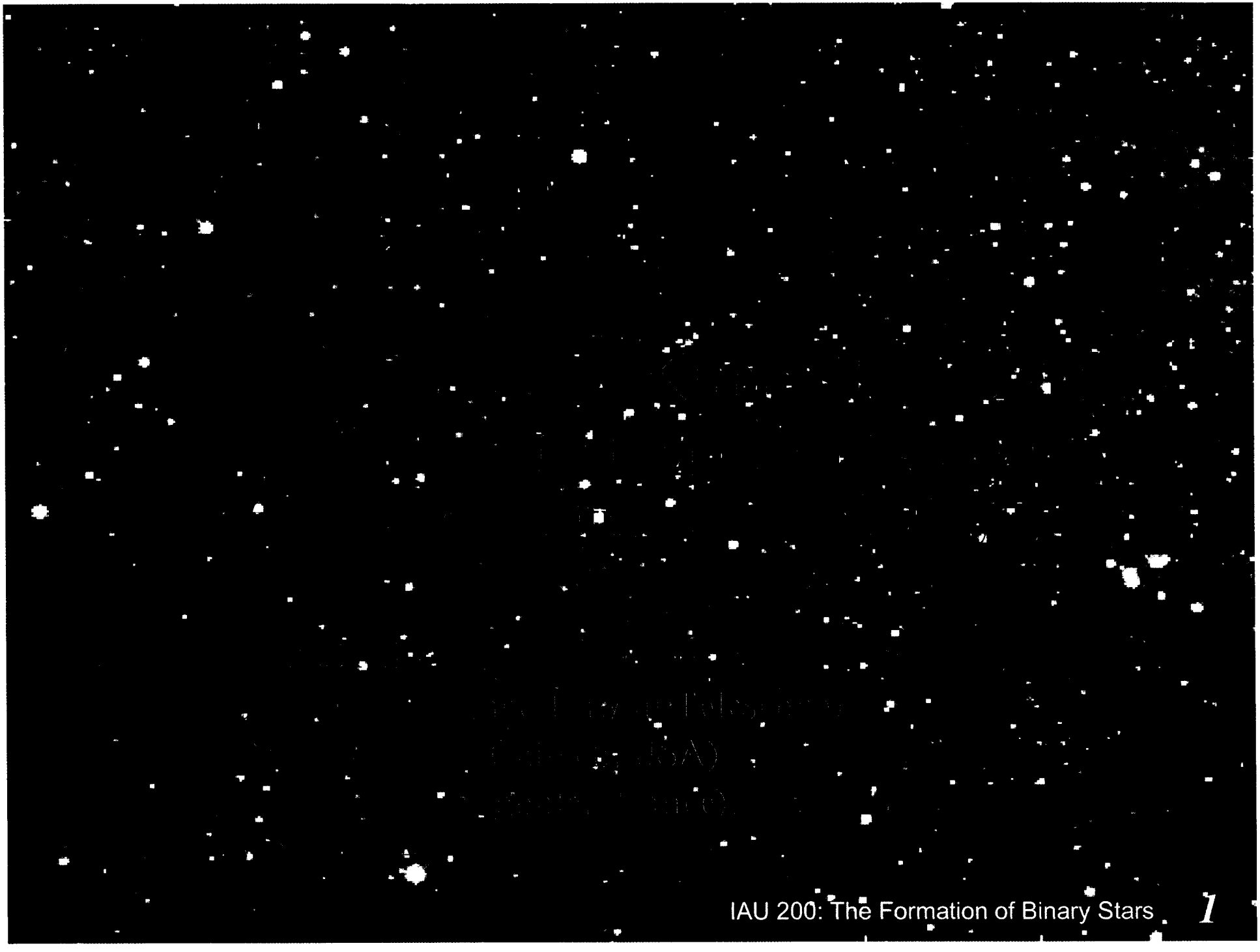


# Outline of the Talk

## Introduction

## Three cases

- a circumbinary disk (UY Aur)
- a circumstellar disk in a binary system (HK Tau)
- a circumstellar disk (TW Hya)

TABLE 2. Disk parameters for CTTSs

| | $R_{out}^{gas}$ (AU) | $R_{out}^{dust}$ (AU) | $i$ | $p$ | $\beta$ | $q$ | $M_{disk}$ ($M_\odot$) | reference |
|---|---|---|---|---|---|---|---|---|
| HH 30 | | 250 | $> 80$ | 0.75 | 1.45 | | 0.006 | [29] |
| HK Tau/c | | 105 | 85 | 0.3 1.5 | 1.2 | | $6 \times 10^{-4}$ | [144] |
| GG Tau | 525 | $> 220$ | 43 | 1.5 | 1.25 | 0.5 | $\sim 0.17$ | [44] |
| DM Tau | 850 | | 33 | $\sim 1.5$ | 1.26 | 0.63 | $\leq 0.025$ | [69] |
| UY Aur | $\sim 1000$ | $> 650$ | 42 | | | | $\leq 0.01$ | [45][34] |
| GM Aur | 525 | $>200$ | 56 | 1.57 | 1.13 | 0.64 | 0.025 | [43] |

The values in this table are difficult to estimate. They come from the best models and observations we found. But the reader should be aware they are subject to change in the future.

# Introduction

**Results presented here collected during surveys, with the Hubble Space Telescope. They are compared with results from Adaptive Optics and millimeter interferometry**

**Estimating the disk parameters is not easy**

**Fraction of disk detected by**

IRAS = >80%

1.3mm flux (single dish) = ~50% (in Taurus)

with HST (cycle 7 snapshot survey) = ~10%

**3 typical cases in what follows**

# The case of HK Tauri

**2.4" binary, both CTTS**

primary is an M1, We(Hα ) = 50A

secondary is an M2, We(Hα) = 13A

**Secondary has disk edge-on, i>85°**

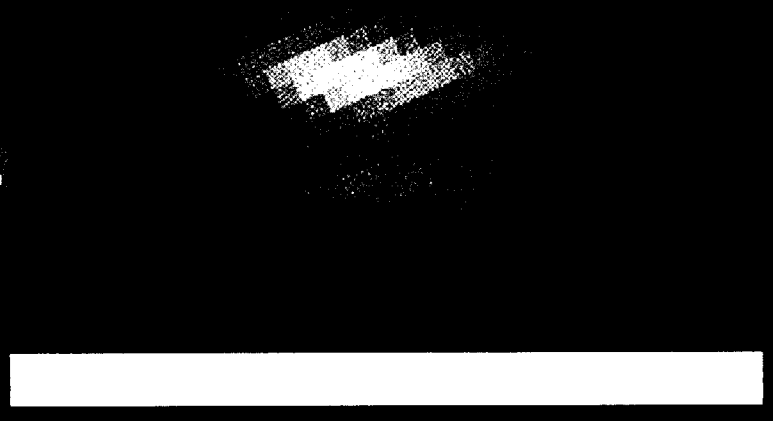
**HK Tau/B is not seen directly, $A_V$>8(**

**Rout = 105AU**

small disk

Truncated by tidal forces?

# HK Tau: Disk Masses from scattered light



**Thickness of dark lane is good indicator of disk mass**

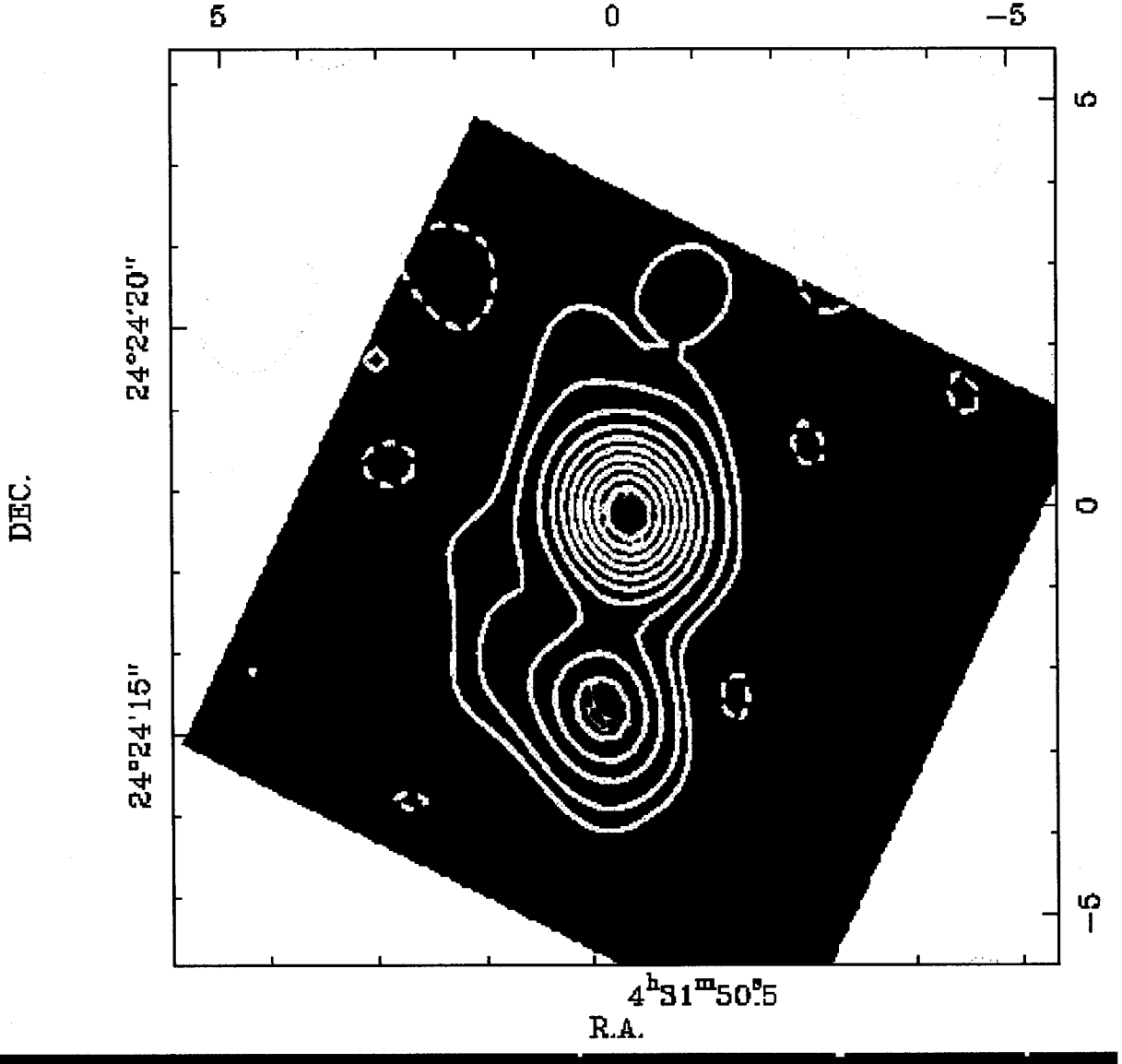
$9 \times 10^{-4} M_{sun}$

**Brightness distribution is asymmetric?**

Similarity with HH30

# HK Tau: Disk Masses from thermal emission

- Low mass of the secondary disk is confirmed by mm mapping
- Primary also has disk, more massive, but not edge-on?



# HK Tau: Misaligned disks?

**Polarimetry suggests non-aligned disks?**

- Jensen, Donar & Mathieu (2000)
- Menard & Chrysostomou, (2000)

# The case of U Y Aurigae

**Binary: 0.88" sep. @ 220°, two CTTS**

- Spectral types: K7 & M2 *(Duchene et al 1999)*

**Second example, after GG Tau, of circumbinary disk/ring**

- Gas disk is large (Rout > 1000AU)
- Thermal emission from dust in disk not detected
  - → *Duvert et al. 1998*
- Dust disk detected in scattered light
  - → *Close et al. 1998*

# UY Aur: A Complex environment

**Many Structures are visible**

- the circumbinary disk
- a "patch" of complex nebulosity SE of UY Aur
- an inner "arc"
  - → *Most AO structures recovered*

**Disk does not wrap around nicely**

- Radiative transfer effect?

HST F814W, 600sec WF3

# UY Aur: A larger inclination is better

**inclination larger than previously estimated,**

→ $i=65^{o}$ +/- $5^{o}$

**not compatible with AO data**

**allows to explain;**

back/front intensity contrast

gas emission in the central gap

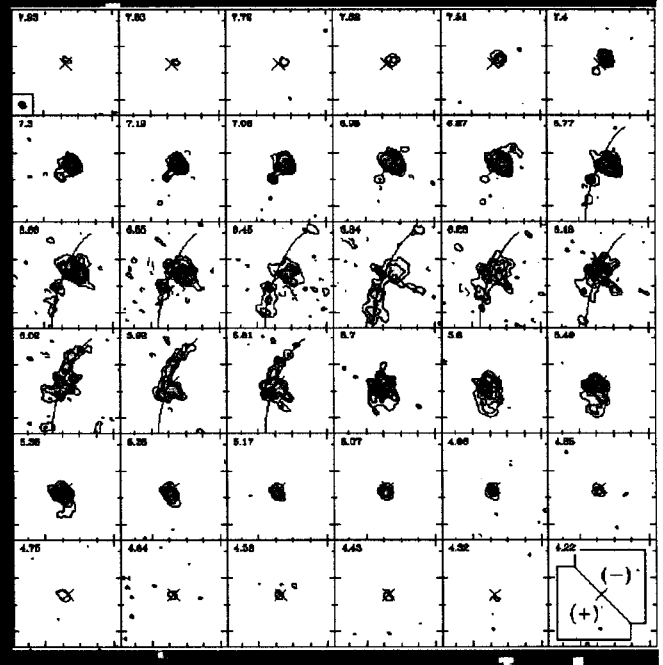
smaller central mass needed

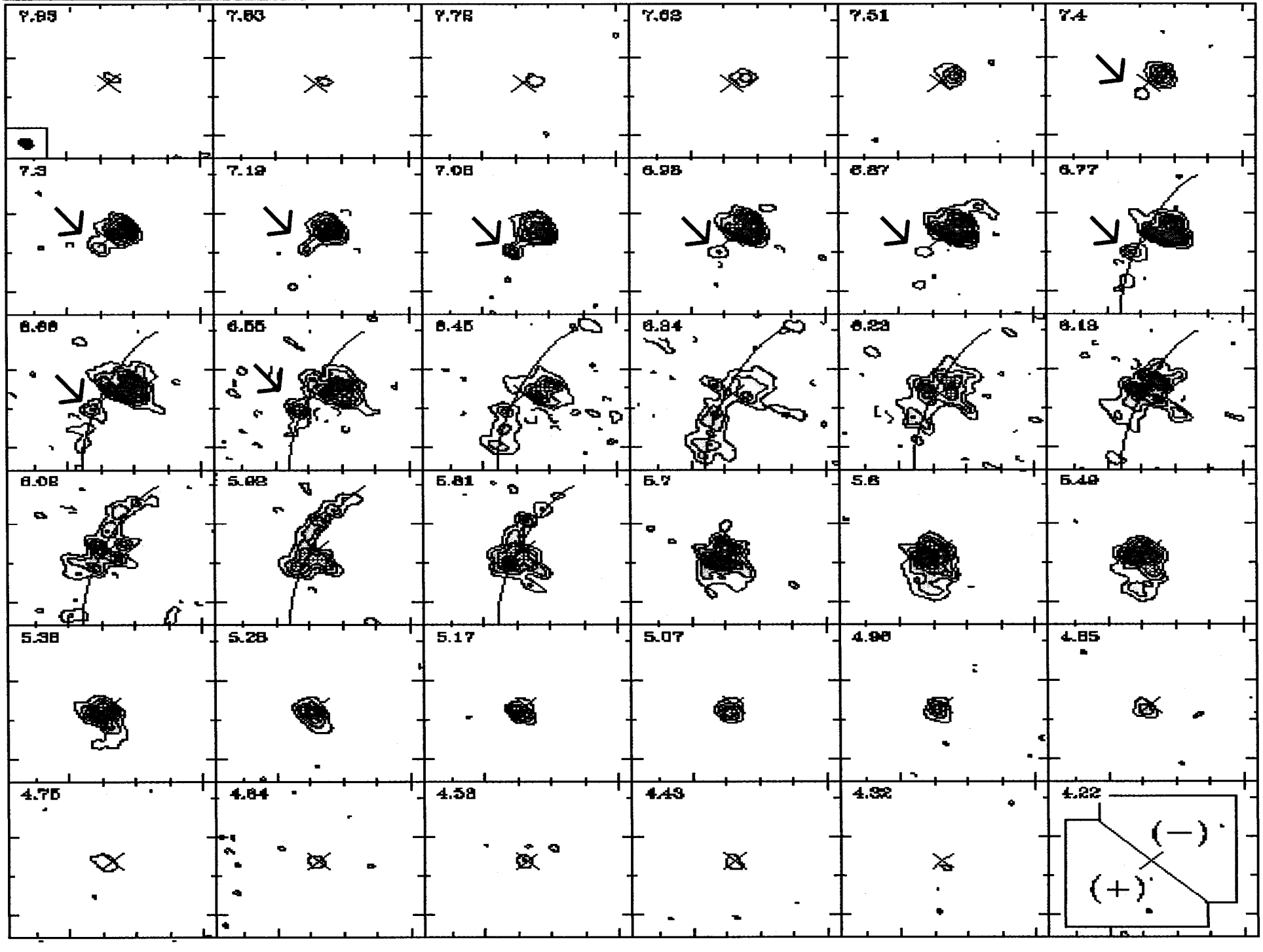
dynamic mass more in agreement w/evolutionary tracks

# UY Aur: What is that "clump"?

**Motions of the gas is complex and multiple components are detected:**

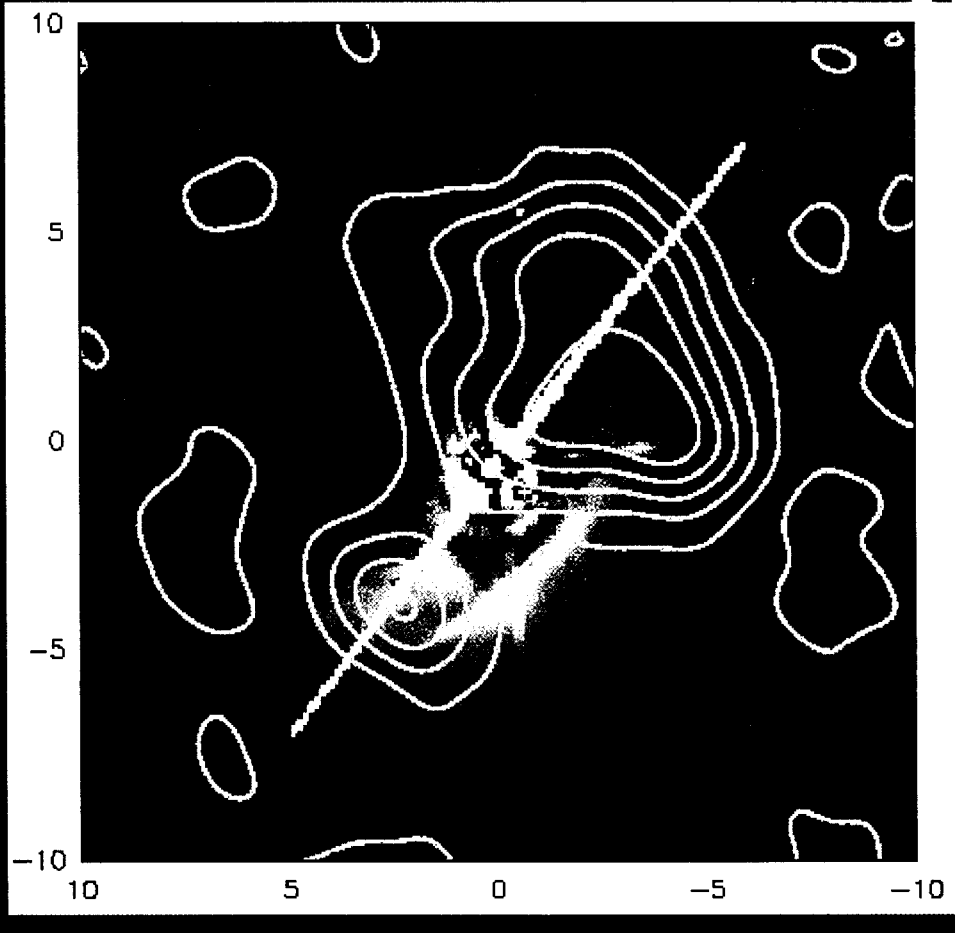
- A Keplerian disk
- A Streamer
- A "knot" of emission, no spatial motion
  - velocity width > 1.0 km/sec
  - not part of Keplerian motion




7.95
7.83
7.76
7.62
7.51
7.4
7.3
7.19
7.08
6.98
6.87
6.77
6.66
6.55
6.45
6.34
6.23
6.13
6.02
5.92
5.81
5.7
5.6
5.49
5.38
5.28
5.17
5.07
4.96
4.85
4.75
4.64
4.53
4.43
4.32
4.22
(−)
(+)

# UY Aur: What is that "clump"?

- **Motion of the gas is complex**
  - multiple components are detected
- **"Clump" coincides with a feature in the $^{13}CO(2\text{-}1)$ channel maps**



# The case of TW Hydrae

**TW Hya is a CTTS**

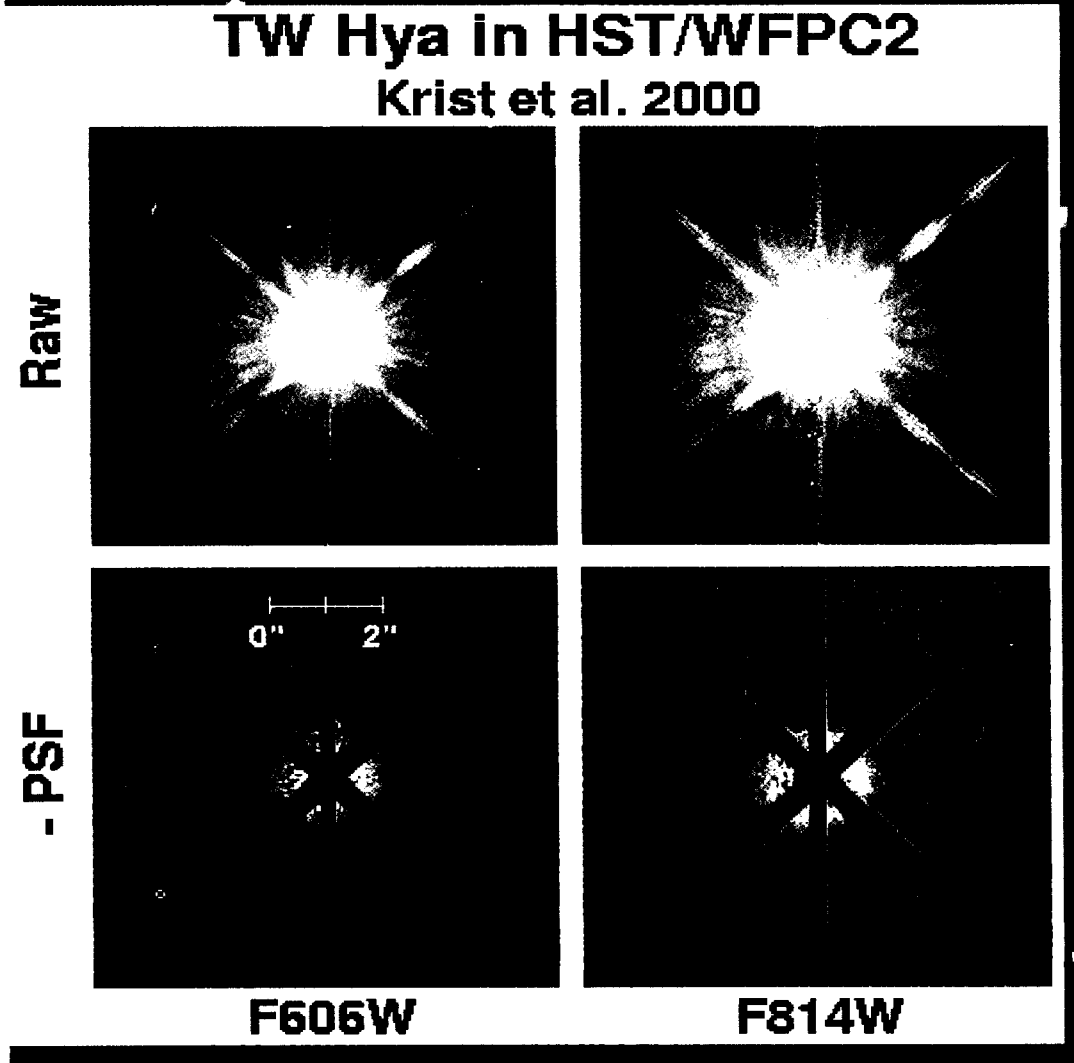
- Spectral type = K7Ve
- Hα is strong and variable
- IR and mm excesses
- Photometrically variable, P=2.196d, amplitude larger in blue
  - → *hot spots from accretion*

**no molecular cloud nearby**

**Distance is 56.4+/-7pc (Hipparcos)**

- TW Hya is one of oldest CTTS known = 10-20Myr

# TW Hya: A Pole-on Disk!!!



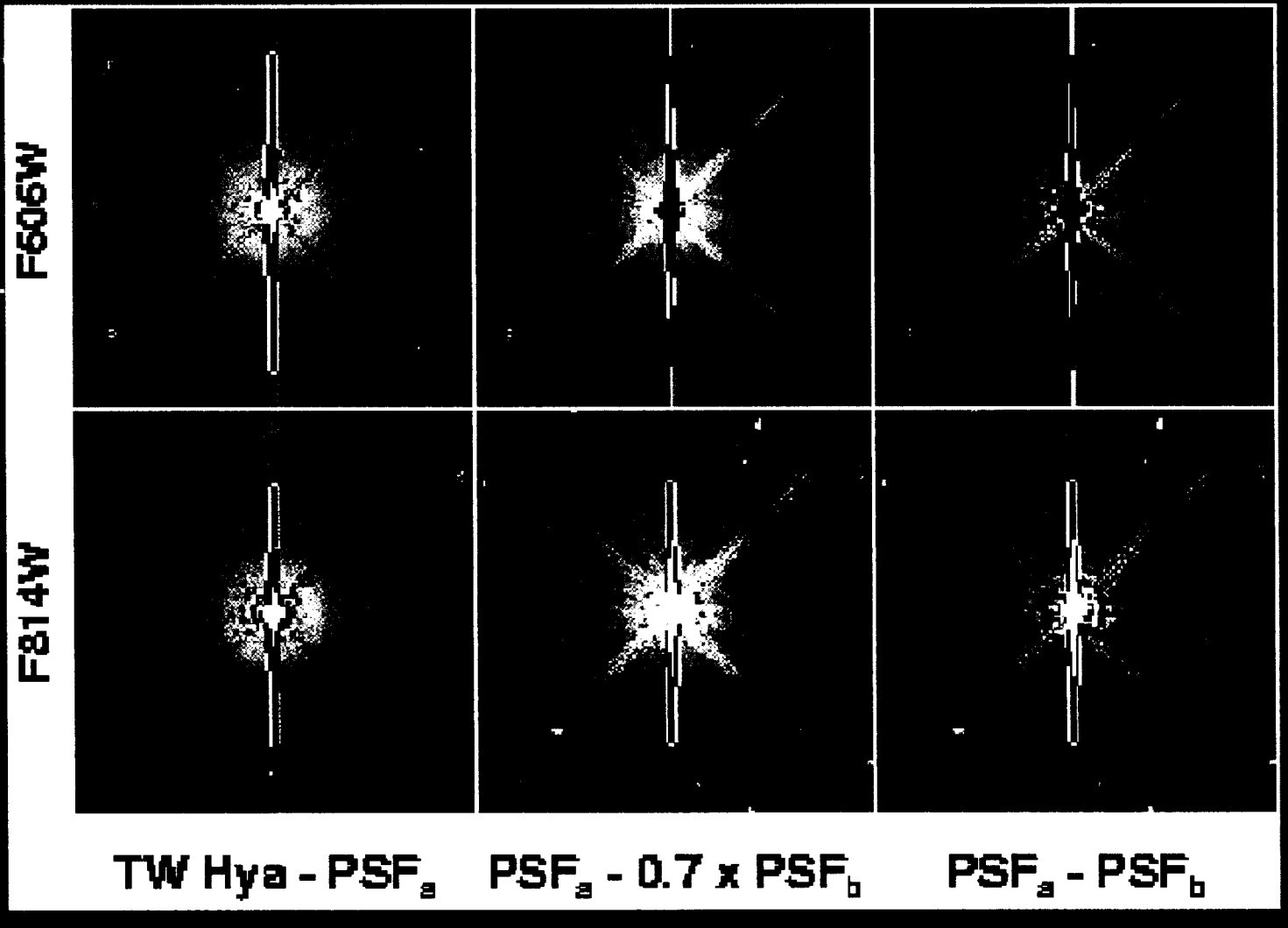

**Unexpected !**

- i=0°,
- azimutal symmetry
- difficult to isolate from PSF

Lucky the distance is small

→ *would have missed it at 140pc*

# TW Hya: Not a PSF-Subtraction Artifact



# TW Hya: The Dust Mass in the Disk

**Previous estimates:**

From CO: 3 X $10^{-5}$ $M_{sun}$, significant depletion (300!)

→ *Kastner et al. 1997*

From 800μm : ~45$M_{earth}$

→ *Weintraub et al. 1989*

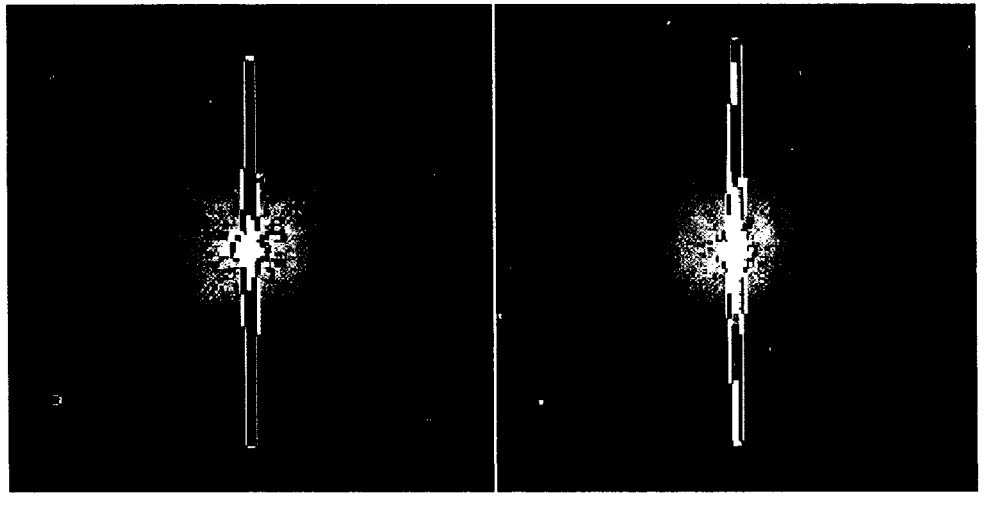
**Our estimate, from scattered light models:**

30 $M_{earth}$ for the dust only

**What is the total disk mass?**

Depends on gas/dust ratio

→ *not clear yet*



TW Hya - $PSF_a$ ($PSF_a$ + Model) - $PSF_b$

# Summary

**Numerous high resolution images of disks available**

- wide range of inclination covered

**multi-wavelength approach possible**

→ *very important*

**Results on CTTS Disks summarized in**

Menard & Bertout (1999) Crete II meeting

Close PPIV

| | $R_{out}^{dust}$ (AU) | $R_{out}^{gas}$ (AU) | $i$ | $p$ | $\beta$ | $q$ | $M_{disk}$ ($M_\odot$) |
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| UY Aur | ~ 1000 | > 650 | 65 | | | | ≤ 0.01 |
| GM Aur | 525 | >200 | 56 | 1.57 | 1.18 | 0.64 | 0.025 |
| TW Hya | | 240 | <10 | | 1.125 | | 0.009 |

# What's next???

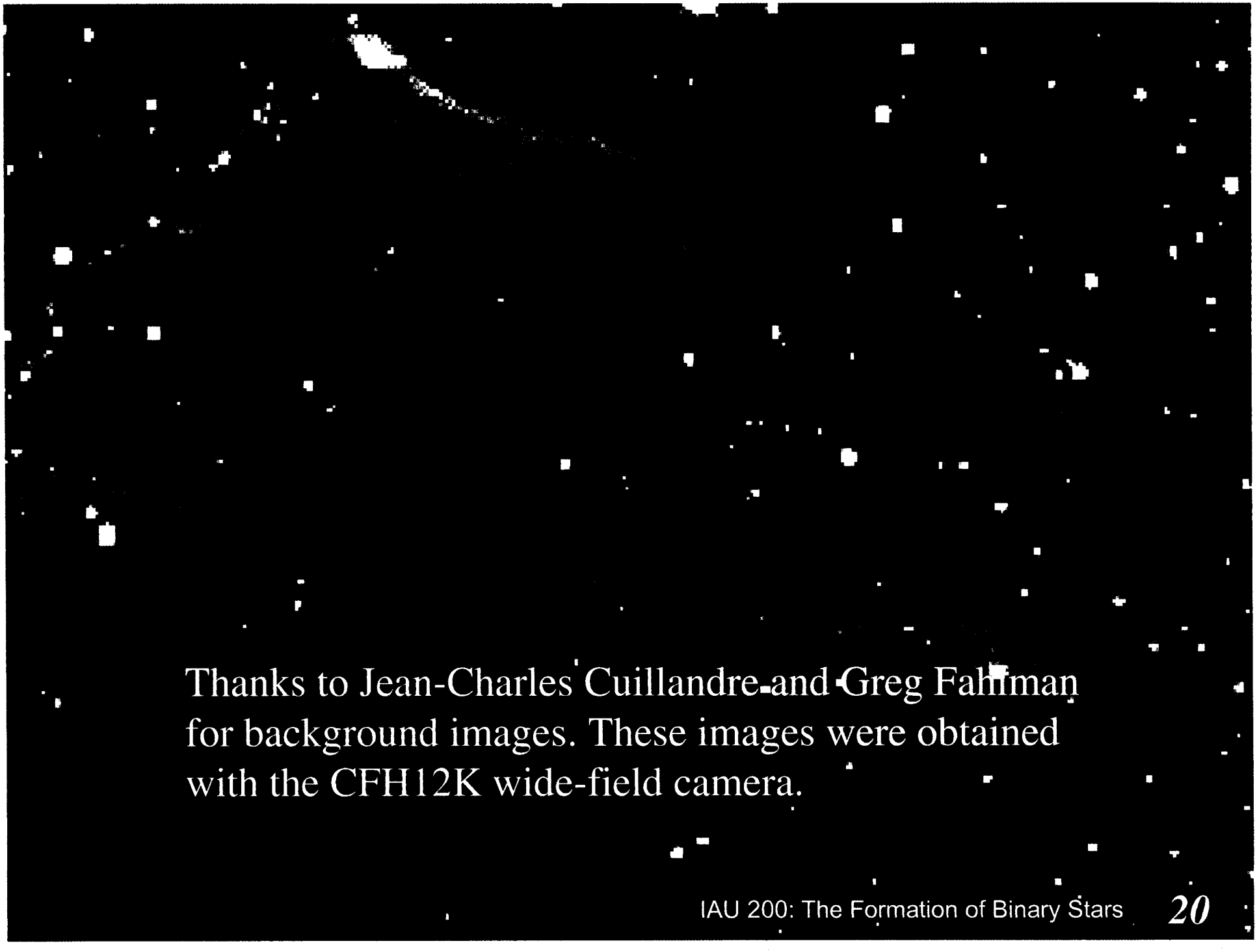
**Why are they so difficult to image?**

Low detection rate with HST and AO

**How do these disks evolve?**

See poster by Augereau et al.

**How do Planetesimals/Planets form?**



Thanks to Jean-Charles Cuillandre and Greg Fahlman for background images. These images were obtained with the CFH12K wide-field camera.